

Introduction to Metamorphic Rock

Lecture #14



- Midterm exam will be held on Monday, 7 March 2011 at K209 from 12:30 – 1:30 pm.
- Igneous & sedimentary rock.



True & False

1. Sediment forms as a result of rock weathering.
2. Clastic sedimentary rocks do not contain particles that have been altered as a result of chemical weathering.
3. Weathering is an important part of the process whereby sediment becomes sedimentary rock.
4. Sedimentary rocks never contain valuable natural resources because they are highly weathered.
5. Sediments only form as a result of the weathering of igneous rocks.



6. Quartz is a common component of sedimentary rocks because it is resistant to chemical weathering.
7. There is no upper limit to the size a sediment particle can have.
8. Chemical sedimentary rocks are formed as a result of chemical weathering of other rocks.
9. Chemical sedimentary rocks typically form as precipitates from solutions.
10. Boulders cannot be transported or deposited to form sedimentary rocks.



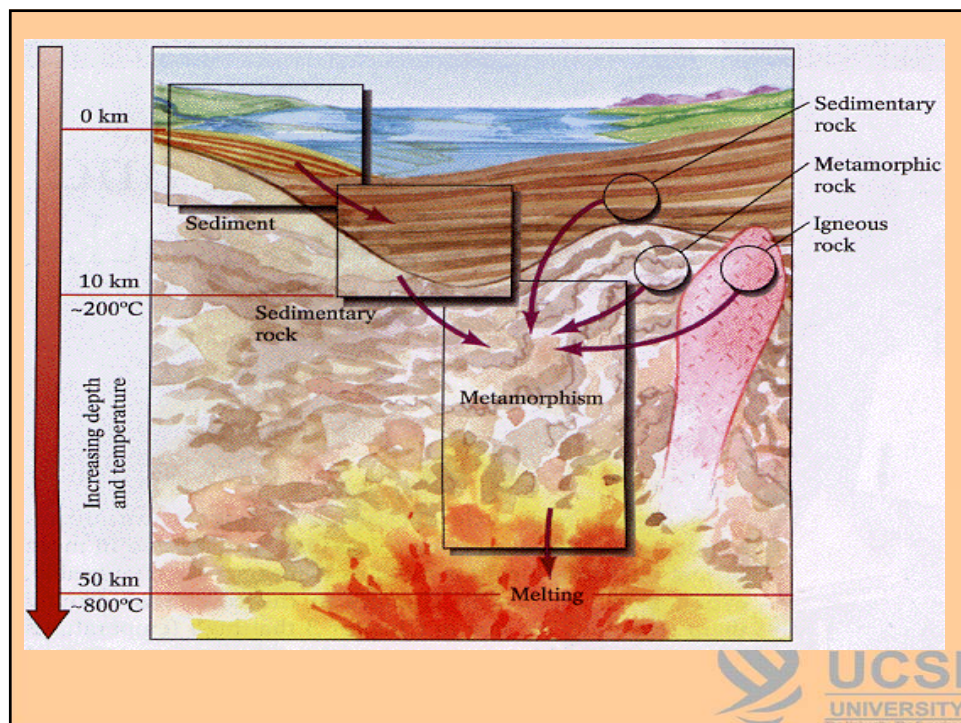
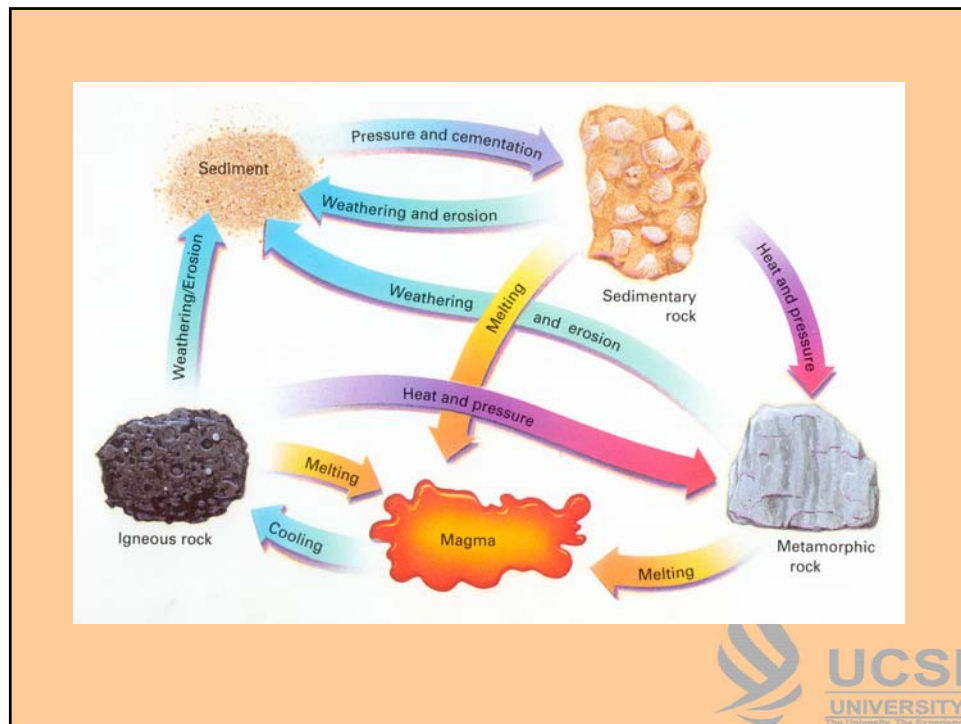
Short Essay

- Explain and describe steps that involves in formation of clastic sedimentary rock! [20 marks]
- Explain the differences between diagenesis and lithification on sedimentary rock! [20 marks]
- Explain what you know about the mechanical weathering! [20 marks]
- There are four different type of sedimentary rock; clastic, chemical, bio-chemical, and organic. Describe the common classification that being used for the clastic sedimentary rock! [20 marks]
- Explain what you know about the graded bedding structure on sedimentary rock! [20 marks]



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Metamorphic Rock

- Metamorphism → meta = change
→ morph = form
- All kinds of rocks can be subjected to changes in temperature and/or pressure. They can be heated and/or deformed so that their appearance change drastically.
- Solid state → not in wet state (melting)
- Texture and mineral composition change



Example: a clay rich sedimentary rock (a shale) can be metamorphosed to a coarse grained, banded rock containing shiny micas, quartz and grains of garnet (a garnet mica schist).



Why need to study the metamorphic rocks?

- Exposed metamorphic rocks make up large parts of continents
- Contain minerals in metamorphic rocks give clues about the conditions existing when they formed
- Used widely as building materials and manufacturing.



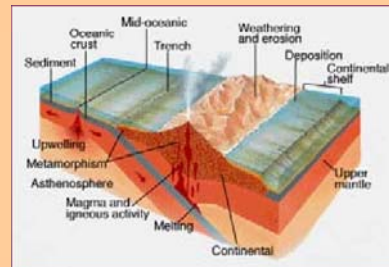
Metamorphism –cause and effects

- Heat
- Pressure
- Chemical Fluids



Heat

- Increases the rate of chemical reactions that produce different minerals
- Sources:
 - » Intrusive magma
 - » Deep burial along subduction zones
 - » Gradient Geothermal



- Not all metamorphic rock change on the chemical composition.
 - Ex: pure limestone consists of calcite → heated → calcite grain boundaries migrate and increases → solid state → textural change → marble.
- Most rocks will form new minerals during metamorphism.
 - Ex. rock contains clays mineral, are not stable at elevated temperature → contain so much water → break down → mica

Pressure

Source:

- Burial Pressure (Lithostatic pressure)
- Tectonic pressure
- Pressure along faults zone



Burial Pressure

- Lithostatic pressure results from the weight of overlying rocks
- Mineral grains are more closely packed
- Recrystallization may occur, producing smaller and denser minerals
- Differential pressure results from unequal forces applied to the rock



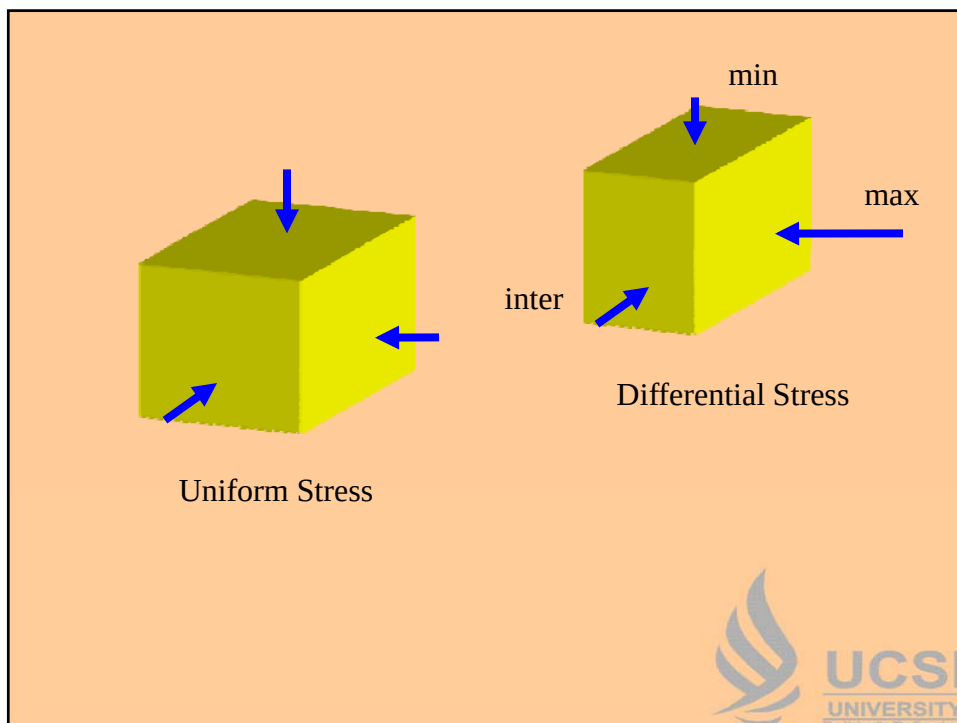
Pressure

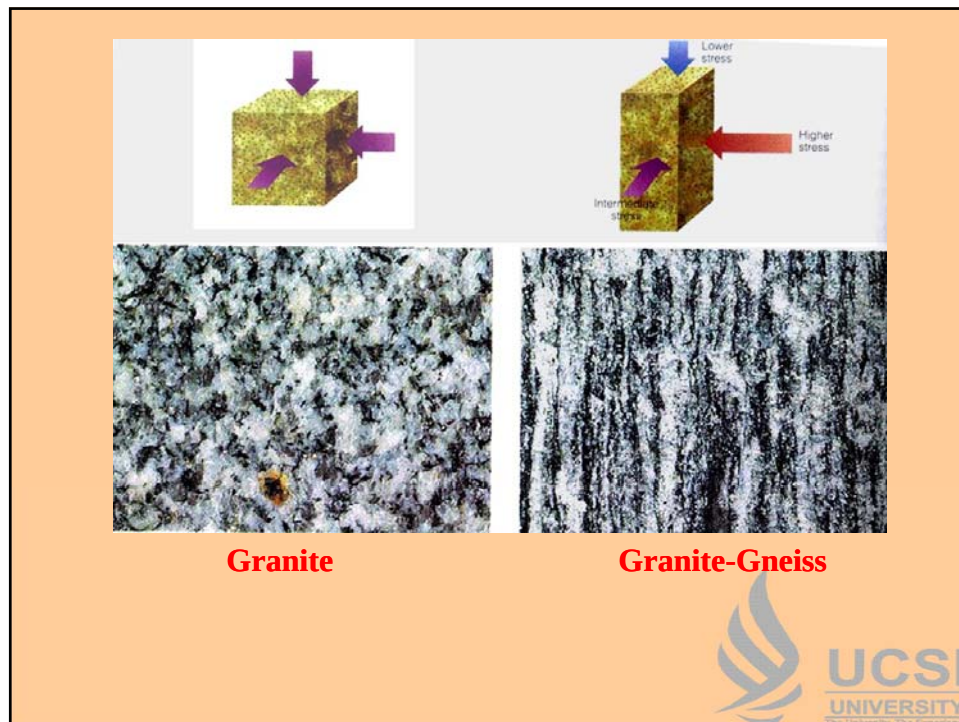
UNIFORM PRESSURE

- increases with depth due to increase in overburden.
- acts vertically downwards and affects the volume of both liquid & solids.
- high temperature is also associated with (due to depth factor)
- Lithostatic pressure- due to overburden

DIRECT or Differential PRESSURE

- increases with depth up to some extent, effective in the upper part of the crust.
- acts in all direction and affects only on solids resulting into deformation of shape and change in mineral composition.
- high temperature is not always associated. to depth factor)
- Stress due to tectonic forces

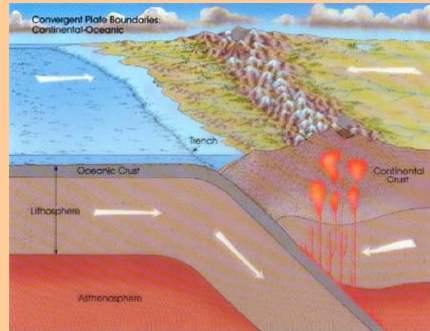




- The effect of pressure alone can produce some metamorphic reactions, but both pressure and temperature increase with depth.
- The geothermal gradient is increase in temperature with depth → varies; depending on the plate tectonic setting → average values for this gradient range 15°C-50°C per km.

Tectonic Pressure

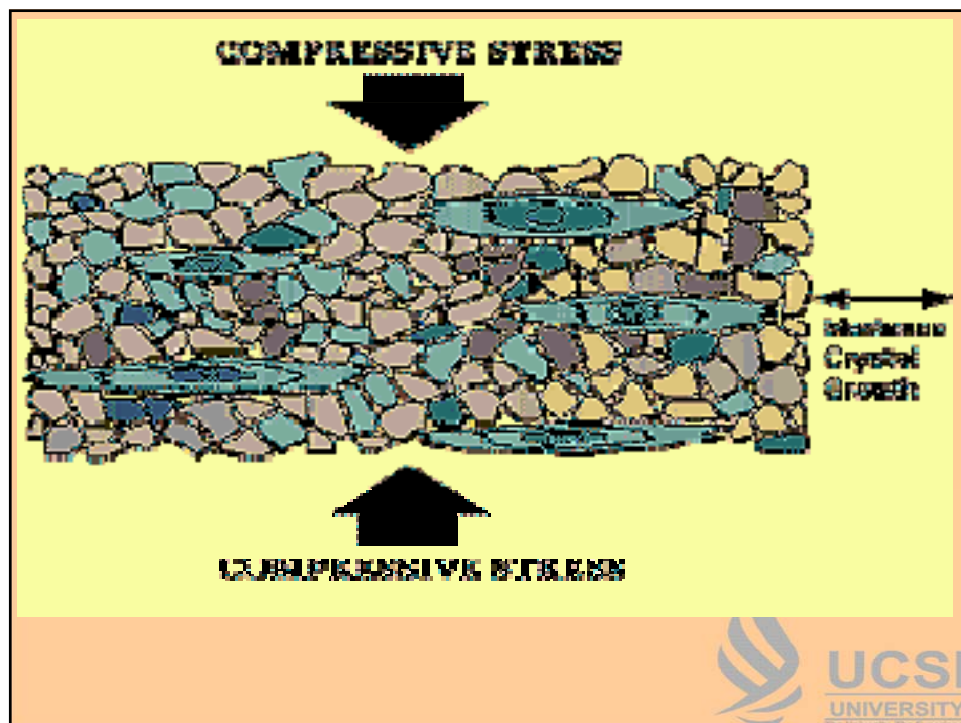
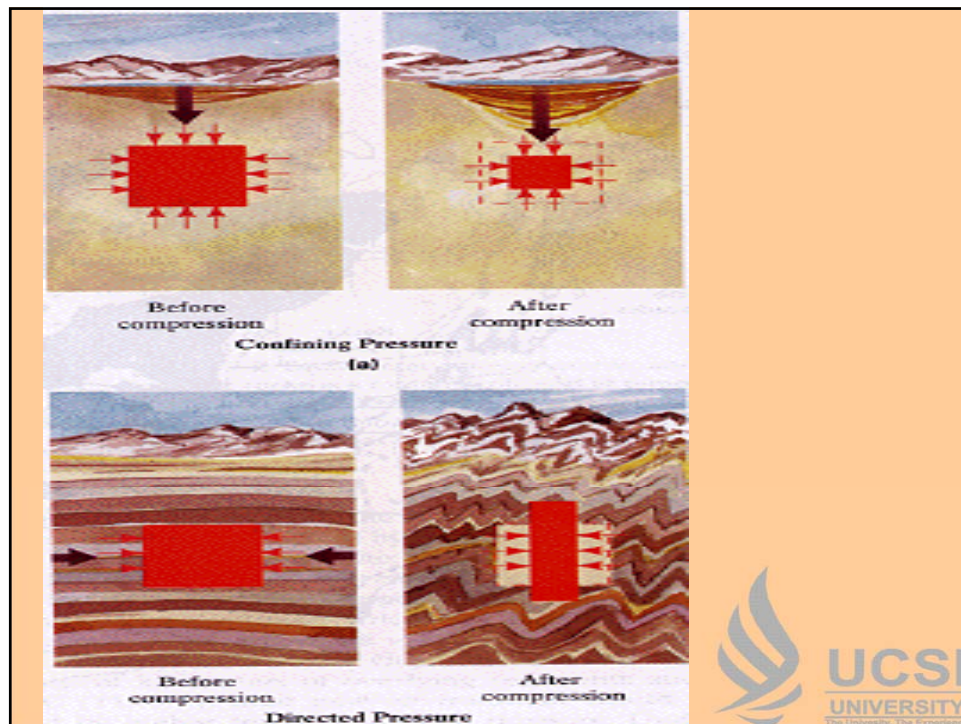
- Associated with continental collision and convergent plate boundaries



Stress

- Normal stress → perpendicular to a surface → compression → tectonic
- Shear stress → move one part of a material sideways relative to another → faults.
- Stress → mineral orientation → foliation





Chemical fluids

- Hydrothermal solutions → hot water with dissolved ions → associated with magma bodies.
- Black smokers → sea water percolates through newly formed oceanic crust, dissolving out metallic sulfide minerals.
 - The hot sea water rises along fractures and pours from vents in the seafloor as black clouds of dark mineral-rich water.
 - Sulfide minerals such as pyrite, sphalerite and galena and copper precipitate when hot water comes in contact with cold sea water.



- Fluid activity
 - Water and carbon dioxide are almost always present in some amount in metamorphic regions
 - These fluids enhance metamorphism by increasing the rate of chemical reactions
- Fluid source
 - Water trapped in the pore space of sedimentary rocks
 - Volatile magmatic fluids
 - Dehydration of water bearing minerals that subjected to heat and pressure.



